Aircrew equipment development process for military aviation

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Abstract

The purpose of this research was to create an effective aircrew equipment development process for military aviation. The aircrew equipment signifies clothing and equipment that aircraft pilots wear or carry when they perform their daily work related to flying.

The research problems were analysis of issues affecting the effectivity of aircrew development, list most important findings and derive a general example of the effective development process. The chosen research method was researcher centric general normative research.

The research was iterative process where process theory and aircrew development environment were studied, analysed and then developed into propositions. This was repeated until all of the parts were studied satisfactorily. The propositions were evaluated by rating them from different viewpoints.

Evaluation of the proposals found effective aircrew development process proposal for military aviation. The chosen proposal is general process example and it could be used as initial process in several nations that have similar scope. The proposed process should then be developed further. This can be achieved by measuring its performance and changing it to be more effective in the environment it will be implemented.

Keywords
Aircrew equipment, development, process, military aviation

Miscellaneous

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Tiivistelmä

Tutkimuksen tarkoitus oli luoda vaikuttava lentovarustekehitysprosessi sotilasilmailua varten. Lentovarusteet ovat lentäjän tai muun lentomiehistön käyttämiä puettavia tai kannettavia asuja ja varusteita, joita käytetään päivittäisissä lentämiseen liittyvissä tehtävissä.

Tutkimusongelmat olivat lentovarustekehitysprosessin vaikuttavuuteen olennaisesti vaikuttavien asioiden kerääminen ja analysointi, niiden kokoaminen sekä priorisointi ja yleisen esimerkki-kehitysprosessin luominen. Tutkimusmenetelmäksi valikoitui tutkijakeskeinen, yleinen normatiivinen tutkimus.

Tutkimus oli iteratiivinen prosessi, jossa prosessiteoriaa ja lentovarusteiden kehitysympäristöä tutkittiin sekä analysoitiin ja lopuksi siitä kehitettiin prosessiehdotuksia. Tätä toistettiin, kunnes riittävä ymmärrystaso kaikista näistä osa-alueista saavutettiin. Prosessiehdotukset arvioitiin pisteyttämällä ne eri perspektiiveistä.

Arvioinnin perusteella tutkimuksessa löydettiin vaikuttava lentovarustekehitysprosessiehdotus sotilasilmailua varten. Valikoitunut prosessiehdotus on yleisluontoinen prosessiesimerkki ja sitä voi käyttää useiden samankaltaisissa ympäristössä toimivien valtioiden lentovarustekehityksessä. Prosessiehdotusta tulisi tosin tässä tapauksessa kehittää edelleen mittaamalla prosessin suorituskykyä ja muuttamalla prosessia tarpeellisessa määrin vastaamaan ympäristöään.

Avainsanat (asiasanat)

Lentovarusteet, kehittäminen, prosessi, sotilasilmailu

Muut tiedot

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1 INTRODUCTION

1.1 Overview

The line of action for Finland's security and defence policy is aimed at safeguarding the country's independence and the society's fundamental democratic values and at promoting the security and welfare of all citizens. Sharing the responsibility for international security and stability and peaceful change in line with shared values and principles is also an integral part of Finland's policy. (Ministry of Defence, Finland, 2010)

The above-mentioned line of action for Finnish security and defence policy could nowadays be from almost any country's defence ministry publication or webpage. Independent states use military forces to protect their society from external threats. The militaries usually consist of different service branches. One of those is usually air force. Air force is a service branch that mainly conducts aerial warfare. It usually has several assets to perform its duties and one of those is aircrafts and pilots who fly the aircrafts. Other service branches, such as army or navy, may have similar assets for their own air operations.

In order to be able to perform their task as human part of a flying weapon system or transport resource fulfilling Ministry of Defence guidelines to serve people of the state, the aircrew needs to be properly equipped.

1.2 Definition and background of aircrew equipment

Aircrew equipment signifies clothing and equipment that pilots wear or carry when they perform their daily work related to flying. The aircrew equipment should provide sufficient ergonomics and comfort, protection against environmental conditions, en-

hance selected abilities such as vision and hearing, work as a man-machine or user interface towards aircraft and its weapon systems. In case of emergency, when pilot needs to eject or disembark the aircraft, aircrew equipment should include survival clothing and equipment for the pilot. Aircrew equipment and survival equipment are an integral entity and in this thesis the latter is included in aircrew equipment category.

Only military aviation aircrew equipment is covered in this research. Military aviation is the use of aircrafts or other flying machines for the purposes of conducting or enabling warfare, including national airlift capacity to provide logistical supply to forces stationed in a theatre or along a front.

Survival has always been part of human life. Clothing has played a significant role in the survival. Wars between tribes, states and religions have been won with great strategies and tactics, but protective clothing and equipment have had their role in conflicts.

Aviation first took place significantly late after clothing and survival needs. Recent research reveals that humans first started to wear clothes around 170 000 years ago. This estimate is based on a study of head and clothing lice (Toups, Kitchen, Light, & Reed, 2010). The first manned flight in western world took place in Paris on the 21st November 1783. Mr. de Rozier and Mr. d'Arlandes flew with hot air balloon developed by Montgolfier brothers. (Encyclopedia Britannica, 2009).

According to Dr. Graham Rood's presentation in SAFE Europe 2010, early aviation development, when aircrafts were slower than the fastest cars or motorcycles, the same clothing was used in all of these means of transports. The clothing was usually made from leather. Since flying was possible only for few people in those early times, some old photos show black suits and dinner jackets worn by the pilots. (Nieminen, 2010). In these days requirements for aircrew equipment are far more different than those days. The equipment must be suitable to be used in fast-jets flying high altitudes and speeds as well as slow-speed, low-level and low-light condition flights with trans-

port aircrafts or helicopters and still offering comfort and protection in case of emergency with man-machine interface between aircrews and aircrafts.

Military pilots' aircrew equipment is not just protective clothing or survival aid. It is also military uniform and its carrier is a representative of military organisation that he/she serves. Besides, this clothing protects individuals from various kinds of fears, including ridicule, fear of being judged as inefficient, stupid, immodest, poor, lacking of good taste or self-respect and fear of being unattractive (Kaiser, 1998, p. 19).

When above-mentioned issues are combined with limited resources available to develop, choose, purchase and maintain a product portfolio suitable for fulfilling the needs of users and logistics resources things get difficult. This thesis aims to shed light on this matter and provide methods, tools and models for effective development process of aircrew equipment.

1.3 Research problem

The purpose of the thesis is to research and analyse issues that affect the efficiency of aircrew equipment development. Based on those findings, the research should provide a list of the most important issues affecting effective development and derive a general example of effective development process with given prerequisites and limitation of scope. The term effective can be described as relation between the process outcomes per resources used (Laamanen & Tinnilä, 2002, p. 47). Besides effective, the process should be efficient. The efficient means maximum total value of outputs from any given set of input while avoiding waste and doing the right things. (Shepherd, 1990, p. 27)

The research prerequisites are not the same or unique to Finnish Air Force in which I serve, but come close enough to support aircrew equipment development work in Finland. The benefit of using public information sources instead of following tightly Finnish Air Force's organisation and system here is that this thesis can be unclassified, it

should be more objective and therefore it may be useful for other military or civil organisations as well.

The reason for the research is to provide theoretical background, analysis, methods and model for improving aircrew equipment development in military aviation. Because competitors are developing in their own fronts, a successful organisation should be more effective tomorrow than it is today.

1.4 Limitations of scope and related definitions

The research is limited by scope to a serve primary goal that is to find effective development process of aircrew equipment for military aviation. There are many types of military aviation existing in the world. Various aircrew equipment is used in militaries operating in different environments. Since this research is not country or service branch specific, limitations of scope and related definitions are created to provide initial conditions for the research. They are based on generalisation of armed services, which may resemble Nordic countries in the Europe. The scope and definitions may be subjective, but that should not significantly alter the outcome or usability of the research. Table 1 below shows the limitations of the research scope.

Table 1. Limitations of the scope and related definitions

Nr.	Scope, definition or limitation
1	Should concern clothing or equipment worn, carried or disposable by aircrew of rotary or fixed wing manned aircrafts including helicopters, fast-jets, trainer-, transport- and liaison aircrafts.
2	Should not concern spaceships or very high altitude aircrafts where full pressure suits are in use
3	Should concern peacetime development process with domestic and international air operations
4	Should concern only military aviation
5	Should concern aircrew population of 500 personnel aged between 20 to 55 years.
6	Should concern 8 operating units where aircrew, warehouses and field service functions are located. Distances between the units range from 100km to 800km.
7	Should concern one or more depot units where central warehouse, depot maintenance and repair, management, procurement, logistics, research and development functions are located. Distance between depot and the operating units range from 20km to 700km.
8	Should not concern wartime development process

9	No own manufacturing of the equipment
10	In-house repairs and small scale modifications possible
11	In-house small scale research and development possible
12	Should take account Military Aviation Authority's role in aircrew equipment development and acceptance processes
13	Short-term financing should be planned for each following calendar year, medium-term financing should be planned for the next 5 years each year and long-term planning for the next 20 years in each year.
14	The development process should be implemented in to a typical military organisation model and structure.

1.5 Research method and data collection

The method of this research is general normative research, which is researcher centric. General normative research produces theory of practice for a professional activity, such as design, which can consist of recommendations, rules, standards, algorithms, advices or other tools for improving the object of study. It does not necessarily include any practical operations of development. Normative research aims at improvements, which means that it includes evaluation of the present state of things and also of the direction of future development. By definition, evaluation is only possible from somebody's point of view (Routio, 2007). The point of view in this research is customer and object of study is aircrew equipment development. In the present state, there are no internal recognised development process, rules, recommendations or tools in use.

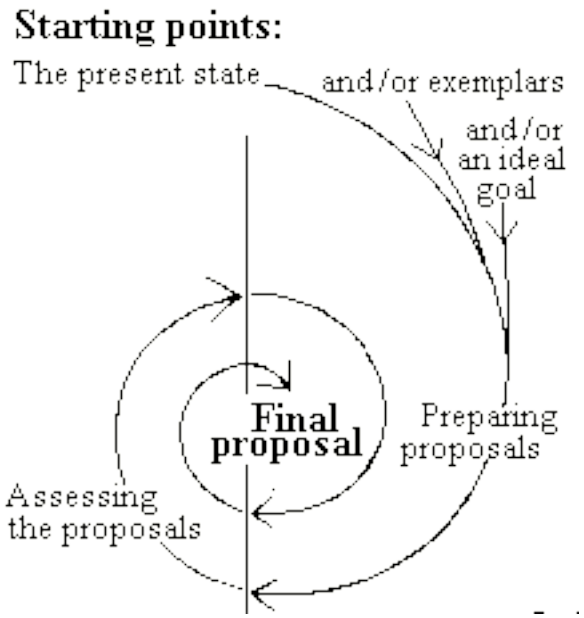

Figure 1. Normative research process (Routio, 2007)

One alternative in normative research is to start the analysis from a description of an ideal state of things, which could perhaps be constructed on the basis of the subjective preferences of the interest groups. Starting points also include the known restrictions and goals for the activity, such as ecology or economy. This approach can be used, either when there is no usable existing model or exemplar on which you could base your proposals. The known restrictions needed in using this method include the limitations of scope and the definitions described in the earlier chapter. A reliable and generally applicable model has not yet been found for the entire process of normative analysis, but quite often one or more of the logical procedures presented in the table 2 are used in the process. Table 3 introduces the terms used in the table 2. (Routio, 2007).

Table 2. Normative analysis process (Routio, 2007)

Step	Normative analysis process
1.	Analysing requirements
2.	Creating the proposal with the techniques of innovation, planning and design
3.	Evaluating Normative Proposals

The research concentrates studying and introducing the operating environment, finding factors, their relations and effects of relations to effective development process of aircrew equipment for military aviation by applying cross-scientific theories based on existing public literature mentioned in the earlier chapter. Based on these findings, the thesis should suggest ways to improve efficiency in the process, list and prioritise them. A model process for the effective development should be created with arguments based on findings, literature and theory. These suggestions and the model process are the goals of the research.

Table 3. Terms in normative research process introduced in figure 1 and table 2 (Merriam-Webster, 2011)

Term	Description of the term
Assess	Evaluate or estimate the nature, ability, or quality of the term.
Exemplar	Typical example or excellent model.
Ideal	Satisfying one's conception of what is perfect.
Proposal	A plan or suggestion, especially formal or written one, put forward for consideration or discussion by others.
Analysis	An examination of a complex, its elements, and their relations.
Innovation	The introduction of something new (including novelty and utility).
Normative	Of, relating to, or determining norms or standards (normative tests). Conforming to, or based on norms (normative behaviour, normative judgements).
Evaluate	To determine the significance, worth, or condition of the term usually by careful appraisal and study.

1.6 Definition of analysis and application in qualitative research

Merriam-Webster online dictionary suggests that analysis is an examination of a complex, its elements, and their relations and statement of such analysis (Merriam-

Webster, 2011). The analysis is thus a process of breaking complex topic into smaller pieces in order to gain better a understanding of and processing it piece by piece.

In qualitative research material collection and analysis often progress simultaneously. Analysis is being conducted during the collection and writing process. The purpose of qualitative research is multifaceted analysis, which processes research material subjectively by focusing certain objects through theories. The analysis should provide observations that are interpreted and lead to conclusions through synthesis. (Virta, 2007, p. 32), (Hirsijärvi;Remes;& Sajavaara, 1997).

1.7 Literature review

There is not much if any literature, studies, books, reviews or journals directly concerning effective development process for aircrew equipment. Therefore, there is a need to combine literature from various fields of studies, assess and apply these theories to provide answers to the research questions. The various fields of studies that would apply would be e.g. systems engineering, social psychology, logistics, aviation medicine, military operation studies, climate and environmental conditions, organisational studies, management science and development of military clothing.

Information sources for the research can be found in articles, research, literature, NATO unclassified public source documents, EU and national legislation, procurement process and competition, estimated or modelled resources available for the development including user-, operational-, tactical- and environmental requirements collection.

2 PROCESS MANAGEMENT

2.1 What is process management

Process management means management practises used for identifying and developing a set or chain of activities (e.g. processes), which are important to the success of an organisation. (Laamanen & Tinnilä, 2002, p. 12).

When pursuing high efficiency, it is not enough to identify and develop processes. Management and organisation may need to be completely re-organised to support effective business processes (Harmon, 2007, p. 110).

2.2 Process

A process is a set of logically related repeated activities and resources needed to transform inputs into outputs. At best, the processes go from customer to customer through departmental and organisational boundaries. (Laamanen & Tinnilä, 2002, pp. 61-62).

The processes belong to Network of Processes. Those in turn belong under Value Network, which consists of Stakeholders and Capability. Activities, that belong to a process and Tasks, which belong to an Activity are along with Process and Network of Processes, part of a company's operating system. (Laamanen & Tinnilä, 2002, p. 36). This process hierarchy is depicted in figure 2.

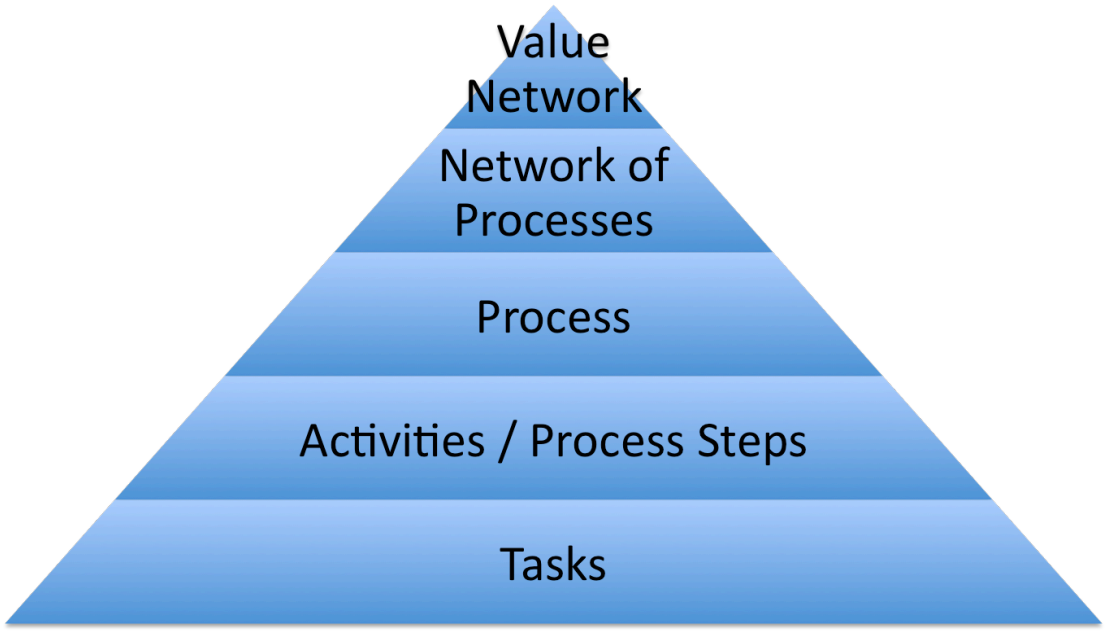

Figure 2. Process hierarchy

2.3 Project

Project is a temporary endeavour undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and an end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists. Temporary does not generally apply to the product, service, or result created by the project. Projects can also have social, economic, and environmental impacts that far outlast the projects themselves. (Project Management Institute, 2008, p. 5)

Althought projects are unique in nature, e.g. company procedures, quality instructions and processes may bring repetitive elements to projects. An ongoing work effect is generally a repetitive process. This repetition does not change the fundamental uniqueness of the project work. (Project Management Institute, 2008, p. 5)

2.4 Customers and Users

According to Laamanen and Tinnilä, a customer is the recipient of the product and service process. Those customers include business to consumer (B2C) customers and business to business (B2B) customers. An internal customer is often understood to mean a performer of the next activity within the organisation. (Laamanen & Tinnilä, 2002, pp. 43-44)

However, in my opinion customer definition must include transaction such as money in additional to the definition above. Therefore a customer is the recipient of the product and service process that he or she pays for or otherwise exchange value related to the product or service. Internal customer may pay for the product or service through management accounting arrangements such as using Enterprise Resource Planning systems.

If one would modify the above-mentioned definition of Laamanen and Tinnilä, it could be re-written to “a user is the recipient of the product and service process that the user does not directly pay for ”. In reference book System Engineering – Coping with Complexity, the term User Requirements is discussed instead of Customer Requirements. For example: “The needs of operational users are defined in the user requirements”.(Stevens, Brook, Jackson, & Arnold, 1998, p. 21). The term User Requirements backs up difference between customer and user. They both belong to stakeholders group.

Therefore, aircrews in the military aviation would be users of the aircrew equipment and the real customers would be the taxpayers that finance the security services such as defence forces.

2.5 Stakeholders

Stakeholders are the individuals and groups who have an interest in the organisation and, therefore, may wish to influence aspects of the purpose of the organisation

(Lynch, 2009, p. 61). In earlier chapter "Research method and data collection" there was a mention about "subjective preferences of the interest groups". The interest groups apply to the stakeholder groups.

Table 4. An example of stakeholders and their expectations (Lynch, 2009, p. 233)

Nr	Stakeholder	Primary expectation	Secondary expectation
1	Owners	Financial return	Added value
2	Employees	Pay	Work satisfaction, training
3	Customers	Supply of goods and services	Quality
4	Creditors	Creditworthiness	Payment on time
5	Suppliers	Payment	Long-term relationship
6	Community	Safety and security	Contribution to community
7	Government	Compliance	Improved competitiveness

The stakeholder can be internal and external to the organisation. Stakeholder management is all about relationship management.(Jeston & Nelis, 2006, p. 255) However, there are less possibilities for relationship management in public sector.

The table 4 above and table 5 below give examples of stakeholders for an organisation. In public sector, the stakeholders and their expectations differ from those described above. For example, the owners of defence forces may not think that financial return would be their primary expectation. However, this might be possible e.g. in

those military organisations that gain rights for land areas rich in natural resources for their owners.

Stakeholders can set requirements for a system, products, services or capabilities. That is why identification of stakeholders is important for the organisation. The identification needs attention to internal and external environment of the organisation.

Table 5. An example of stakeholders for an armoured personnel carrier (Pasivirta & Kosola, 2005, pp. 73-75)

Nr	**Stakeholder**
1	System user (Järjestelmän käyttäjä)
2	End user (Järjestelmän loppukäyttäjä)
3	Maintenance organisation (Järjestelmän ylläpitäjä)
4	Depot (Järjestelmän varastoija)
5	Training organisation (Koulutusorganisaatio)
6	Authorities (Viranomaiset)
7	Procurement organisation (Hankintaorganisaatio)
8	Railway operator (Valtion Rautatiet)
9	Parliament (Eduskunta)
10	Ministry of Foreign Affairs (Ulkoministeriö)

11	Industry (Valmistava teollisuus)
12	Vehicle Operations Controllers (Ajojärjestelijät)

2.6 Sufficient and appropriate resources

Concept of sustainable competitive advantage underpins resource-based analysis in business strategy. However, public sector has traditionally been regarded as not engaging in competitive activities. (Lynch, 2009, p. 660)

Public sector resource analysis needs to assess whether sufficient and appropriate resources are available for delivering the purposes set by the state. One of the main difficulties rests with the words ”sufficient and appropriate”. (Lynch, 2009, p. 661). A question that emerges is what kind of resources the aircrew equipment development in military aviation really requires. In Lynch’s (2009) opinion ”public resources need to be analysed for their ability to deliver the maximum benefit for the least cost. ’Benefit’ here has a broader social definition than simply delivering shareholder profitability in the private sector.” (Lynch, 2009, p. 663). Therefore military aviation organisations should reserve sufficient and appropriate resources for effective aircrew Equipment development to fulfill the recognised needs and reach the set goals.

Resources may be sufficient, but a process can still be inefficient. This may be due to excess resources. How to define an upper limit for the resources? The upper limit or maximum can depend on variations in resource use e.g. peak work load. The peak load reduction can be carried out by careful job timing-, resource-, work time-, holiday- and work load planning.

When pursuing for efficiency, the maximum resource use would be exceeded at least in the point where output does not increase at the same rate as resources are added. An

example of this would be number of developed products compared to resources. Another indication of excess resources would be that the system in which the development process occurs, starts to slow down due to excess load through interfaces from the development process. Example of this could be e.g. complaints from stakeholders that their own tasks suffer from serving the development process. Then the system costs start to exceed the benefits. There are also other indicators for excess and insufficient resources, such as work satisfaction disturbances, sick leaves, work accidents, personnel turnover rate and idle time at work.

2.7 Human resources

The development process should have sufficient and appropriate human resources at disposal. This can be understood as manpower, skills and knowledge. Assuming that manpower is given by the organisation and cannot be altered, the skills and knowledge can be developed e.g. by training to meet the requirements of the process.

From process organisation point of view, human resources should have been appointed to roles instead of positions. Skills and knowledge of a person should be suitable for the role he or she is appointed to. Process description should indicate what kind of skills and knowledge is required to each role. (Laamanen, 2001, p. 122)

2.8 Financial resources, planning periods and budgeting

Financial planning periods were given in the research pre-requisites. Those were calendar year based, where 1 year indicated short-term budgeting, 5 years medium-term budgeting and 20 years indicated long-term budgeting. The development process and projects evolving from the process should be budgeted and cost-controlled separately.

2.8.1 Process financial planning period

Process financial planning period depends on the need for process cycle-time. The standard process cycle-time should be fine-tuned to equal nearest applicable of the planning periods. This is due to budgeting and resource allocation decisions for the development process and projects evolving the process.

Since development in the aircrew equipment market is continuous, reasonable planning time is short-term thus one calendar year. This reasonable development time may have an exception if there is strong influence from stakeholders to spend excess budget before fiscal year ends.

2.8.2 Process budgeting

Since there should be only minor variation in good development process, the process costs should also be relatively easy to forecast when there is no any variation in the process. The development process costs related to aircrew equipment usually consist of:

1. Labour costs

2. Overhead costs e.g. such as travel, general administration and information management costs

3. Information collection costs (seminars, meetings, trade-fairs, magazines, associations, product and service evaluations)

The process budgeting should not include any project budgeting. It should mainly consist of deskwork, general overhead, travelling and seminar costs. The process disturbances such as unexpected events may increase the process costs.

2.8.3 Project financial planning period

The projects that evolve from the development process should follow financial planning of the process and therefore be fixed in the short-term budgeting. However, very large quantity orders, long delivery time equipment or otherwise very complex systems related projects might need longer term financial planning. An example of this kind of complex system might be helmet mounted cueing system.

The short-term planning period together with strict rules about accrual items in the organisation may favour or even force procurement implementation to early phase of the period. This should be taken into account when creating or improving processes.

2.8.4 Project budgeting

Project budgeting should be planned in a process step of the development process. Aircrew equipment projects that evolve from the development process may be very different in nature and in overall cost. For example after recognising the need, requirement collection and analysis, product evaluation, procurement and commissioning of simple IR flash for only 50 persons with an item price less than 100 Euros is relatively simple and low-cost project. On the contrary, the same process for flight vest integrated VHF/UHF/GPS-antenna system connected to a new CSAR personal locator beacon for all aircrew population would be completely in another class. This is especially notable when it comes to the amount of stakeholders, cost, complexity, validation, verification, instructions, training efforts and time consumed before the product is in operational use.

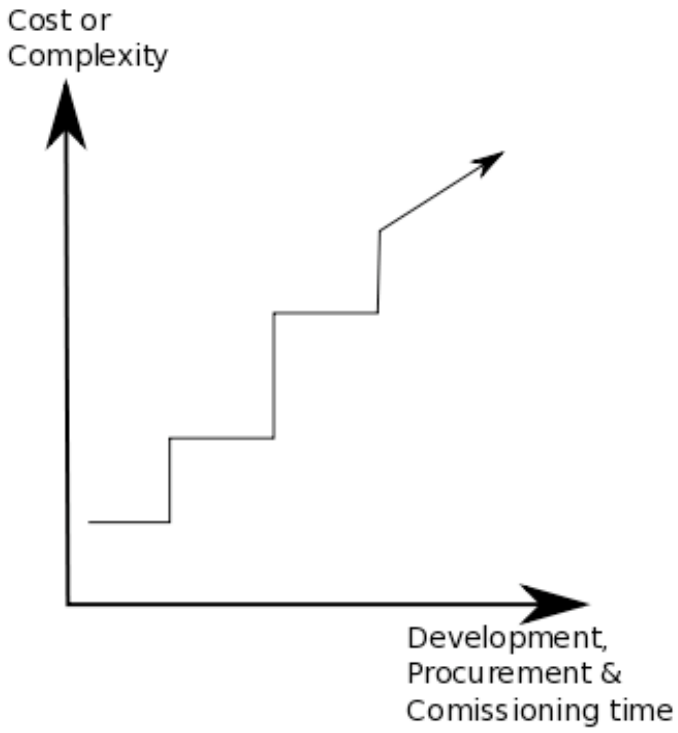

Figure 3. Project cost or complexity vs. time consumption

As discussed in previous chapter, the project financial planning period may be the same as process, but due to some projects' relatively high costs the decision-making process might set other requirements. One of those requirements might be time to complete all the steps and get the approvals needed from decision makers required by norms and administration. Therefore the higher the costs, risks, complexity and financial decision level required, the more advance is required for decision-making. Figure 3 illustrates this phenomenon and table 6 shows an example of it.

Table 6. An example of project decision-making time span vs. cost and complexity

Deci-sion levels	Financial Decision (Euros)	Complexity of project	Advance (weeks)	Decision authority
5	Negotiable	Highly complex	> 8	Ministry of Defence
4	> 5 000 000	Highly complex	< 8	Commander, Air Force
3	> 4 000 000	Highly complex	< 4	Director, Air Force Material Command
2	> 500 000	complex	< 2	Chief of Division
1	> 50 000	moderate	< 1	Chief of Section

3 ENVIRONMENT FOR AIRCREW EQUIPMENT DEVELOPMENT

3.1 Military organisation and decision making

Military organisations are known to be bureaucratic-hierarchical. In the bureaucratic organisation, decision making is usually vertically arranged in the same way as in line and staff organisation or at least is based on this organisation model.

In bureaucratic organisations the decisions and management should be impersonal, objective and based on norms. (Krogars, 1998, p. 42). Line-, line and staff- and matrix organisations have centralised control. These organisations assume that superiors have greater knowledge than subordinates. (Ristimäki, 2002, p. 31).

3.2 Global changes in organisations

Recent global trends in reducing and rearranging organisations' resources have also changed management capabilities of bureaucratic organisations. Often in these cases personnel is decided to be reduced to save costs. Superiors in line organisation start to take more work from their overloaded specialist subordinates and therefore resources for management functions will reduce. At the same time reductions in general administrative labour may transfer part of their tasks to each employee in the company as self service. This will fragmentate and add complexity to the employees' work and makes direct labour costs more difficult to measure and control.

The cost cut trends have their goals in improving efficiency and coping with less labour. However, organisations need to focus on the flows and relationships that actually add value and produce products for customers. Indeed in many cases, maximizing departmental efficiency actually reduces efficiency of the whole process. (Harmon, 2007, p. 76). Departments don't produce efficiency. Value chains and processes can be measured and improved against output thus improving efficiency. When dramatically reducing staff headcount, any organisation will face tough strategic and quality of service challenges if it does not change organisation arrangements, job desriptions and improve processes to increase productivity.

3.3 Processes in military organisation

Military organisation model is usually defined by others. In this research it is line and staff functional organisation and it is considered as given. Processes can be implemented to line and staff functional organisation where line organisation

management provides skilled resources, human resource development, general management and control for processes. Decision making that is described in process description is done according to roles and descriptions in the process, not by managers in the line management. (Laamanen, 2001, p. 120)

3.4 Legislation, control, organisations and politics

3.4.1 European Union and national legislation

European Union and many national states have legislation whose purpose is to increase competition in the market of goods and services. This legislation may require issuing public tenders that usually increases competition, promotes fairness of procurement and introduces lower prices for the goods and services to be procured. It may also delay development projects with procurement bureaucracy, increase procurement and contract management skills needed to handle public tenders and legislation related to it.

Nation states, trade blocks or unions may impose trade restrictions that affect the import of goods from certain nations or organisations. Also exporting to certain nations or organisations may be restricted. These restrictions may be unilaterally or multilaterally imposed. Examples of such trade restrictions are export control systems, dual-use systems, export licences, quota systems and boycotts. (Czinkota & Ronkainen, 2004, pp. 135-141).

3.4.2 NATO and NAMSA

NATO is the biggest political and military alliance in the world consisting of 28 member countries and several other partners. Common military operation capability of 28 member states requires common practises. According to NATO Standardization Agency (NSA) website: “Shortly after the establishment of NATO, it was recognized that the co-ordinated development of policies, procedures and equipment of the member nations held great potential for enhancing the military effectiveness and efficiency

of the fledgling Alliance. As a result, the Military Agency for Standardization (MAS) was established in London in January 1951 for the purpose of fostering the standardization of operational and administrative practices and war material." Later on Military Agency for Standardization was renamed to NATO Standardization Agency. (NATO Standardization Agency, 2011).

Since interoperability with NATO is crucial to members and partners, NATO standards should be followed in all military procurement and development projects. NATO Standardization Agreements for procedures and systems and equipment components, known as STANAGs are good source for the interoperability requirements and technical specifications for developing products and preparing procurements.

NAMSA, which is NATO's premier logistics agency, provides cooperative logistics services to its customers. The customers are NATO bodies, member countries and part of Partnership for Peace countries. These services consist of consolidation, centralization and competition. The services bring benefits for the customers that are listed in the table 7 below. (NATO Maintenance and Supply Agency, 2011).

Table 7. Benefits using NAMSA (NATO Maintenance and Supply Agency, 2011)

Benefit	Description
Consolidation	NAMSA consolidates identical or similar logistics requirements expressed by two or more of its customers. The consolidation of requirements means larger quantities can be ordered, resulting in lower prices.
Centralization	By placing their requirements with NAMSA, customers have the added advantage of addressing a single entity rather than having to deal with a multitude of suppliers.
Competition	NAMSA's international competitive bidding allows a widest market to be scoured to obtain the best quality at the lowest prices.
Direct procurement	E.g. Finnish national legislation currently allows direct purchases from NAMSA without the need to arrange public tenders.

3.4.3 Military Aviation Authority

According to the Ministry of Defence in the UK, The Military Aviation Authority (MAA) is the organisation that regulates, audits and assures all aspects of military aviation. It is an integrated suite of regulatory, surveillance, inspection and assurance functions across the Defence air operating and technical domains, to underpin the safe design and use of military air systems within the Defence operating context. (Ministry of Defence, United Kingdom, 2011).

Military Aviation Authorities are national regulatory organisations. They have regulatory authority in their county into national or international military aircrafts. The Military Aviation Organisations may issue regulations for the development, testing, approval and use of aircrew equipment.

3.5 Technical and scientific environment

Scientific research should provide information about the environment and evidence to support decision-making in organisations. Scope of technical environment for development of aircrew equipment is wide because there are so many various technologies used in the equipment. It deals with all the senses of humans as well as physiological aspects. It includes mechanic, electronics, pneumatics, optics, acoustics etc. These areas of expertise are getting more complex as integration with aircraft systems will deepen.

Traditional system integration has comprised from anti-G, breathing and communication systems. Now it has expanded to targeting, visualisation, night vision, 3-D sound alerting system and Man-Machine-Interface systems. The technical environment is highly cross-scientific development environment and therefore vast knowledge and contacts are needed for successful development of the equipment. New areas of study for the future could include:

- Nanotechnology
- Deep integration
- Enhanced reality
- Vital function real-time monitoring (pulse, body temp, etc.)
- Adaptive body heat and sweat transfer technology

3.6 Business and market environment

3.6.1 Competition in markets

According to Merriam-Webster competition is the effort of two or more parties acting independently to secure the business of a third party by offering the most favourable terms (Merriam-Webster, 2011). It is a market condition in which a large number of independent buyers and sellers compete for similar commodities dealing freely with each other, and retain the right of entry and exit from the market. Competition restrain prices, forces firms to be efficient, and stimulates innovation (Shepherd, 1990, pp. 1,3).

It depends on a product in aircrew equipment supply market if there is real competition or not. There is less competition in the complex, most expensive and technologically advanced products than in simpler, cheaper and bulk equipment market. An example of a complex and expensive product would be a helmet mounted cueing system.

Firms seek higher market shares in order to gain higher profits. If one or several firms gain high market shares, they can obtain high profits by increasing volume that lowers costs, setting higher prices and restricting output. Their monopoly or tight oligopoly power imposes social costs such as a degree of inefficiency, a slowing of innovation, unfair shifts in income and wealth, and less freedom of choice. (Shepherd, 1990, p. 3).

There is a trend or tendency in aircrew equipment market to gain market shares by purchasing other companies in the business. An example of this is Survitec Group, which was established in 2000. Today the group has at least around ten companies and brands that it has acquired over the years. An American private equity firm Warburg Pincus, LLC owns the Survitec Group. (Survitec Group, 2011), (Warburg Pincus LLC, 2011).

3.6.2 Trends in the market

Shortened product life cycles, and the fragmentation of formerly standard products, impel a shift towards more agile and customer responsible behaviour by the suppliers of goods and services. According to a article of John Storey, Caroline Emberson and David Reade in International Journal of Operations and Production (2005), these dynamics are especially notable in the context of the fashion industry and clothing retail in general. (Mayle, 2006, p. 91). However, functional products like aircrew equipment and clothing that have easily forecasted demand should not have such agility and customer responsiveness based on trends. Interoperability requirements reduce the speed of product development due to the system inertia and politics.

Shortened product life cycles and introduction to market times lead to mass-customisation in order to satisfy customers and simultaneously keep product costs in a profitable level (Czinkota & Ronkainen, 2004, p. 614). The mass customisation and uncontrolled product variations may bring issues for product life cycle support and configuration management.

3.6.3 International events

International events where suppliers, researchers, customers and other stakeholders meet around aircrew equipment or related products are very important for personnel involved with the development. The events offer excellent opportunities for performing market research, negotiating with suppliers, learning about operations, tactics and use, finding business partners, exchanging experiences, gaining knowledge and making friends.

World is full of international events and since aircrew equipment discipline is very cross-scientific in nature, it would be impossible to collect huge up-to-date list of recommended international events. Therefore a few such international events are collected in table 8.

Table 8. International events concerning aircrew equipment

Event	Description	Webpage
SAFE Europe Symposium	The annual Survival and Flight Equipment Association's (Europe) symposium and exhibition provide an excellent forum for the exchange of information in the field of Survival and Flight Equipment for both Military and Civil applications.	http://www.safeeurope.co.uk/
SAFE Association Symposium	The Symposium provides an internationally attended marketplace for the exchange of technical information, product and service exhibitions, and the showcasing of industry capabilities for meeting challenges in vehicular occupant protection and personnel-worn safety equipment.	http://safeassociation.com/symposium.htm
PIA Symposium	PIA Symposium is biennial Parachute Industry Association's symposium. Seminars and exhibition offer good opportunities to meet suppliers, research market and learn from others.	http://pia.com/2011/
Farnborough International Air Show	The biennial air show is one of the world's most iconic global aviation events taking place in the UK.	http://www.farnborough.com/

The International Paris Air Show	The International Paris Air Show (Paris Le Bourget) has been the premier and largest worldwide event dedicated to the aviation and space industry with some 2,000 exhibitors, 138,000 trade visitors, 3,000 journalists and 200 official delegations.	http://www.paris-air-show.com/en

3.7 Social Environment and clothing

3.7.1 Clothing and appearance management

Clothing is a persistent interest centre in everyone's life. Clothes not only serve individual, social-psychological, and physical needs but also are cultural representations and art forms. Clothing relates to how individuals are socialised in a society, and how appearance is a factor in the development of their self-concepts. (Kaiser, 1998, pp. 22-23). Social class is a factor in the purchase and use of clothing. Fashions flow down from the upper classes to the lower classes, with the tendency for social classes to imitate those immediately above them in order to move up the social ladders. Military organisation and its members consist of individuals that belong to more than one social class. (Kaiser, 1998, p. 14)

"Easily identified as 'aircrew in the making' by the white flashes in their forage caps, they were popular with the girls of the district" (Lewis, 2000, s. 25). This was an extract of Bruce Lewis's book called Aircrew – The story of the men who flew the bombers. The above-mentioned extract support thoughts of William James who wrote, "The old saying – that the human person is composed of three parts – soul, body and clothes – is more than a joke" (Aholainen, 2003, p. 5).

Although adding social science into this research may seem unrelated, but it is an important part of understanding the development of the aircrew needs. The user require-

ments are partly borne from the needs related to social aspects. Military organisations encourage soldiers to follow organisational norms in their uniform dress. These kinds of organisational culture effectively take advantage of the visual aspects, which in the armed services reinforces togetherness and uniformity with its work dress (Aholainen, 2003, p. 9). However, it is not this simple to understand aircrew clothing.

Social groups form when two or more persons consider themselves as members of the same social category. A group is perceived as having common characteristics or a common fate only because other groups are present in its environment. These common characteristics may be e.g. common symbols like clothes people wear at work that may determine group membership at least partly. (Aholainen, 2003). Additional examples of such symbols are aircrew clothing, equipment and badges.

Since aircrew clothing is not only protective clothing, but also uniform and a symbol for the social group, it will affect user requirements or user needs. This is partly due to upholding or raising the group's social status. Members of the subordinate social group may dress like the dominant group or the group they aspire to (Aholainen, 2003, p. 35). An example of this could be that a young non-commissioned officer may want to dress like a pilot officer in an air force.

3.7.2 Social norms and development

Social norms can be understood as ways or methods of providing behaviour that is reflected or derived from values. Therefore the norms and rules that obligate to a certain behaviour are forced by sanctions. There is special significance in social groups, which can be evaluated as a closed system and there is great interdependence between the individuals in the group. (Krogars, 1998, p. 56)

Social groups in military organisations are usually closed. There are several cases where the closed military norm system has efficiently prevented very talented leaders and experts from advancing their career because of behaviour that does differ from the norm in the social group. If the difference is unacceptable it has great influence in the

development of the organisation in the future. (Krogars, 1998, p. 56). It may have negative influence to military performance in peacetime and crises. More specifically, it may deter talented research and development experts and leaders in military aviation and its development.

3.8 Climate, environmental conditions and geography

3.8.1 Climate and environmental conditions

Human body needs protection against weather and climatic conditions. The climatic conditions in the Earth vary depending on the geographical location and time of year. The conditions are part of the environment where aircrew equipment is being used. Therefore special attention must be addressed in order to develop suitable clothing and equipment configurations for different climatic conditions.

According to NATO STANAG 2895 (Extreme Climatic Conditions and Derived Conditions for use in defining design/test criteria for NATO forces materiel) the world climate is divided into eleven climatic categories. Eight of the categories pertaining to the land surface (termed A1, A2, A3, C0, C1, C2, C3 and C4 respectively) are defined with temperatures as the principle consideration while the remaining three (termed B1, B2 and B3 respectively) represent climates in which high humidity accompanied by a warm temperature is the outstanding characteristic. For the sea surface, two categories (termed M1 and M3 respectively) are defined with temperature as the principal consideration while the third (termed M2) represents sea climates in which a warm temperature is accompanied by high humidity. The STANAG 2895 climatic categories are collected into table 9 below. (NATO, 1990, ss. A-1).

Table 9. Climatic categories according to NATO STANAG 2895 (NATO, 1990, p. A-1)

Nr.	Category	Short description
1	A1	Extreme Hot Dry
2	A2	Hot Dry
3	A3	Intermediate
4	B1	Wet Warm
5	B2	Wet Hot
6	B3	Humid Hot Coastal Desert
7	C0	Mild Cold
8	C1	Intermediate Cold
9	C2	Cold
10	C3	Severe Cold
11	C4	Extreme Cold
12	M1	Marine Hot
13	M2	Marine Intermediate
14	M3	Marine Cold

Sr. Lt. Noora Repo has studied international operations and climate requirements related to NH90-helicopter aircrew and survival equipment development needs. Repo has divided geographical and climatic conditions in to four (4) categories for different sets of aircrew and survival equipment. Those are mountain-, glazier-, desert-, and tropical climatic categories. (Repo, 2007, pp. 21, 33, 34).

3.8.2 Geography

Since climatic conditions vary depending on the geographical location, it is essential to know the geography of the operating area of flights. This knowledge supports the planning of product portfolios and configurations that meet the prevailing or expected conditions. In addition to this, it is also important to know geography and especially geographic locations and distances between the operating units, depots, field service functions, central warehouses and the units where aircrew equipment are being developed.

If the distance between all units in a relatively small country is short, the stakeholders and people participating into the development process can visit each other, communicate easily face to face and get to know each other. Some scholars suggest that informal information sharing is vital for new product development and that this sharing is facilitated by geographic proximity, which serves to enhance face-to-face communication and the development of strong relational ties (Ganesan;Malter;& Rindfleisch, 2005, s. 44).

Ganesan, Malter and Rindfleisch conclude in their article in Journal of Marketing that "results show that geographic proximity is related to face-to-face communication but is unrelated to relational ties, relational ties moderate several linkages in the path between geographic proximity and new product development, face-to-face communication is less effective than electronic communication as a means of knowledge acquisition, and knowledge content has a greater effect on new product development than knowledge form." (Ganesan;Malter;& Rindfleisch, 2005, s. 55).

3.9 Peacetime operating environment

3.9.1 Domestic operations

Peacetime operating environment usually means that all the functions of the state and business are operating normally. There are no conflict or wartime disturbances in the operations. Peacetime legislation is followed. A country may attend e.g. crisis management operations far beyond country's borders and it is still counted as peacetime. This means that domestic and international supply markets for aircrew equipment are available for procurement. This may not be the case for procurements from a country that is fighting a war. Those countries may apply limitations to arms exports to materially support their own ongoing operations.

Labour strikes, disturbances in transportations, weather conditions, crises due to natural disaster and etc. may disrupt imports, exports and procurement process, but these should only be limited to transportation-, response- and delivery times. Despite the

peacetime, trade wars and barriers between nations and trade blocks may complicate or hinder the procurements.

3.9.2 International operations

International operations are part of defence forces operation area as well as foreign affair politics. This area has traditionally been playground of great powers, but NATO expansion, ever tightening co-operation of nation states with mutual economic and immigration issues have encouraged smaller nations to join international coalition operations and in the same time gain military experience.

There are currently 14 UN led peacekeeping operations and 5 NATO led military operations ongoing around the world. There are dozens countries providing troops for these operations. The operations are being conducted in several climate categories and environmental conditions. (United Nations, 2011), (NATO, 2011). These variations of conditions support the thought that international operations will bring special requirements for the troops clothing and equipment. The aircrew clothing and equipment are no exception to this.

Even as international operations bring their special requirements to the aircrew equipment, most of the development work should not change. The procurement activities should use domestic operation procurement infrastructure, norms, guidelines and resources in order to be centralised and efficient.

3.10 Constant change in the environment

For decades, management research has been dealing with the question of how organisations in increasingly unpredictable environments can manage in the current situation while preparing for the future. While in the past organisations have been primarily avoiding crises and struggling to keep the status quo, today management should see early identification of trends as a factor of gaining and sustaining competitive advantage. (Liebl & Schwarz, 2009, s. 313).

Above-mentioned may seem far-fetched for military organisation developing air-crew equipment. However, since environment is constantly changing and the pace is ever increasing, this must be understood at least in research, procurement, maintenance and life cycle planning.

Nothing is constant in the environment except constant change. To remain successful over long periods, managers, development engineers and organisations should implement both incremental and revolutionary change (Mayle, 2006, p. 170). Following areas are examples of constant change; information technology platforms, tools, organisations, markets, technologies, products resources, generations etc.

4 ANALYSIS OF THE ENVIRONMENT AND ITS REQUIREMENTS FOR THE DEVELOPMENT PROCESS PROPOSALS

4.1 Benefits of applying process management to development of air-crew equipment

Staff and line organisation has functional structures like departments. The organisation model is not originally designed for arranging and managing lateral work flow. From the recognition of customer needs to delivery of solution for customer involving several departments and consisting of products, brands and services would not be efficient and fast through this hierarchical system.

The process thinking and work flow may bring efficiency to the organisation. The process work can deliver the following advantages over functionally arranged work in the organisation (Stevens, Brook, Jackson, & Arnold, 1998, p. 320):

- improved time to market

- more satisfied customers (users)
- earlier delivery of an operational product
- management visibility and control over the development
- a measurable and therefore improveable process
- a process where progress is visible to management
- interoperability, re-use and communication across project

If performance metrics have been defined and applied to measure process performance, the process improvement and comparison between projects becomes possible on the next set of projects. The emphasis when improving processes has to be on reducing complexity and tackling the easy, high-reward parts first. (Stevens, Brook, Jackson, & Arnold, 1998, p. 311).

4.2 Process development

4.2.1 Process development prerequisites and steps

In order to develop processes they must be identified. After the identification the processes should be described. After the description, activities in an organisation should be arranged and implemented according to the processes. If the process measurements are set in place, the processes can be measured and improved. (Laamanen, 2001, p. 50)

If there are not any existing processes to be improved, they must be designed from the scratch. This can replace the identification part of the previously mentioned activities. Table 10 offers an example of process development for an existing process and a process to be created from the scratch.

Table 10. Process development steps for existing and non-existing processes

Step	Description (existing process)	Description (not existing process)
1	Identify all related processes and the process that is going to be developed.	Identify all related existing processes and design the new process from the scratch to the system of processes.
2	Write process description.	Write process description.
3	Measure the process performance.	Implement the process in the organisation.
4	Improve the process based on performance metrics.	Measure the process performance.
5		Improve the process based on performance metric.

4.2.2 Identifying processes as part of a system

Process thinking is subset of systems thinking. System thinking is about understanding organisations and workflow as a whole. Process thinking is about thinking a portion of a system that produces a specific set of results. (Harmon, 2007, p. 76). A system can be presented with process map, where the processes are interlinked together.

Aircrew equipment development is part of a system that produces a specific set of results. Therefore it can be understood and treated as a process. In order to identify

and develop a process, the system or business process together with operating environment, relations and flows should be understood and mapped.

4.2.3 New process design

The business strategy that management has chosen and developed should be the base for the organisation "system" and the processes. The process to be developed would be very different for different strategic choices, such as operational excellence, customer intimacy and product leadership. For example operational excellence strategy requires cost leadership, which means efficient and short lead time development process. On the other hand, product leader strategy would require innovation thus resources in research, flexibility for development process and iterative process. (Jeston & Nelis, 2006, pp. 72-73).

The organisation strategy choice in the military aviation and its effects for the aircrew equipment development are an interesting question and a topic of heavy discussion, where safety aspects would likely be drawn into the conversation. The operational leadership would perhaps mean effective, small variation development process with tight cost control. The product leadership would mean the best ones available and a wide range of products selected for the aircrew disposal with little concern about the costs it would generate.

A process has inputs and outputs. Both come from or lead to other processes in the system. The process designer should answer to him/herself to a few questions that will help to design the process. Examples of those questions are listed in the table 11 below.

Table 11. An example list of questions requiring an answer while designing a new process (Laamanen, 2001, pp. 89-92)

Nr	Question
1	What is this process applied for? What are the process outputs and what inputs are needed to produce the outputs?
2	Who are the process customers (users) and stakeholders? Where do they need or use the process outputs? What kind of requirements do they set for the process?
3	What is the goal of the process (meaning, task, mission)? What are the process success factors? How is the process performance measured?
4	What are the process inputs, products and services? How is the process information managed?
5	What are the process phases and critical steps? What kind of process chart will it be?
6	What are most important roles in the process? Who is the process owner? What are the most important tasks, steps, decisions and responsibilities related to the roles? What are the essential rules related to the process?

4.2.4 Process architecture, value chain, core processes and support processes

Value chain is normally the largest process. It defines a process that begins when the organisation decides to create a new product or service, or when a customer orders a product, and concludes when the customer has it and is satisfied with the product or

service. From any arbitrary process, the larger process that contains it is its super-process. Similarly, the processes contained in the arbitrary process are termed its sub-processes. (Harmon, 2007, p.80).

Process architecture is created by decomposing a value chain into processes and sub-processes (Harmon, 2007, p. 91). The value chain is the core process. Processes can be divided further to core, support and management processes. The core processes add value to the product or service that the organisation is producing for its customer. (Harmon, 2007, p. 86). The customer could be e.g. taxpayers in military aviation. One way to understand this might be core process that adds value by integrating efficiently resources such as aircrafts, command and control systems, weapon systems, know-ledge, skills, plans and people for providing security services.

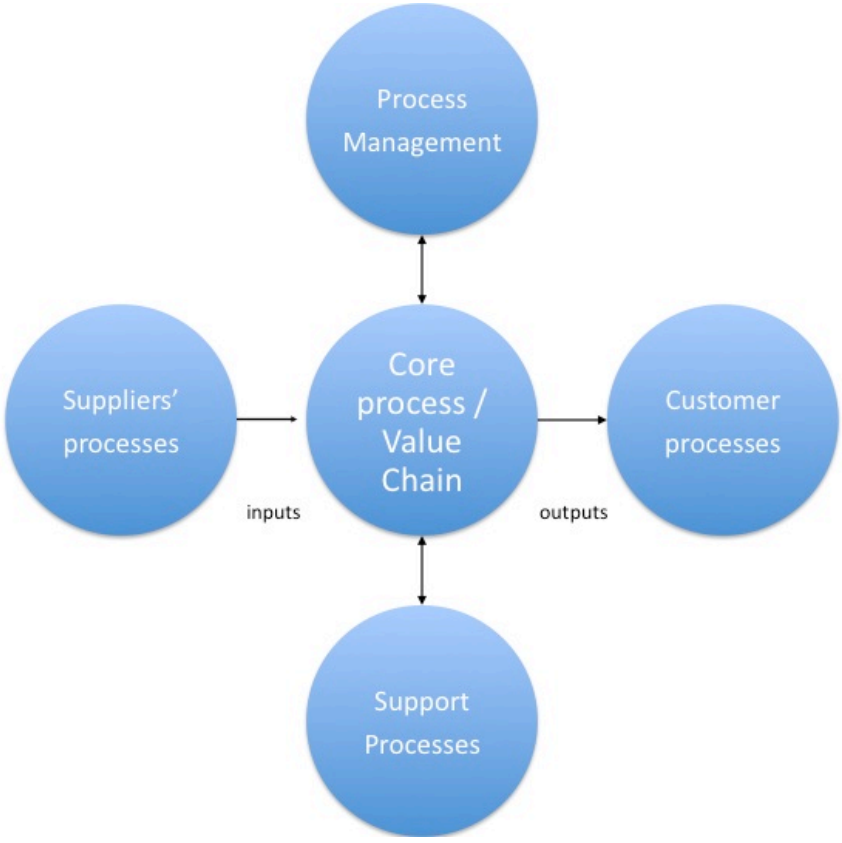

Figure 4. General example of a value chain and a core process

The support processes do not add value, but are necessary for core processes to continue functioning. The support processes support the core processes. Accounting and Information Management are typical support processes. Sometimes the support processes are divided into processes that directly support core processes and management processes that are more generic and where planning, organising, communication, monitoring and control activities are performed. Figure 4 illustrates relation of value chain, support processes, customers and suppliers. (Harmon, 2007, p. 86).

4.2.5 Process description

The processes should be named and described. Naming and descriptions are methods of communicating goals, purpose, process steps, actions and result of the process for people in the organisation (Laamanen, 2001, p. 59).

Good process description helps an organisation to understand its activities and relations. It should include identification, creator, date and approving body or person. Process descriptions are needed for identifying critical process steps. (Laamanen, 2001, pp. 75-76)

4.2.6 Process implementation

Implementation phase is the phase where designed and developed process improvements are realised and brought to life. It is also the phase where change management skills and leadership are needed, if changes to the existing workflow or resources are dramatic. (Jeston & Nelis, 2006, p. 204)

The process can be implemented to an organisation through people. Therefore everything that needs to be done must be communicated to the people in the organisation and make them believe that the process implementation is good for everybody in the organisation.

The communication should be planned respecting the organisation culture. However, Laamanen (Laamanen, 2001, p. 98) suggests following steps for the implementation:

1. Process description introduction
2. Process description evaluation based on agreed criteria (SWOT)
3. Discussion of viewpoints to the process
4. Prioritising the development areas in the process
5. Action plan

4.2.7 Process measurement and improvement

In order to measure and analyse as objectively as possible, measurements should provide numerical data for analysis. If measurements are numerically expressed, then the objectives should be in numerical format as well. Measurement is important because otherwise organisation is managed based on opinion and intuitions. (Laamanen, 2001, p. 149).

Process performance measurements can be measured from various places. Those measurements can measure many variables including e.g. time, cost, quantities, physical properties, views, etc. Some things like innovation and research are difficult to measure directly. (Laamanen, 2001, pp. 151-152).

One of the most important key figures for process success factor is lead-time. Since one should concentrate on easy and high reward parts first, this would definitely be one of them. Lead-time reduction usually brings benefits such as costs reductions, quality improvements and customer satisfaction increase. In order to improve lead-time, it must be measured before and after the process re-design, improvement and implementation. (Laamanen, 2001, p. 153)

Costs are always important in the process measurement. The costs may prove difficult to measure. This is due to cost follow-up system deficiencies and unwillingness to put

a lot of effort to create cost follow-up system for the processes. In addition to direct cost follow-up, capital investment is important especially in production organisations. (Laamanen, 2001, pp. 154-155).

Quantity measurement may measure quantities of e.g. products, ideas, service transactions, people, development products and accidents. If quantity is measured, then there should be set goals, preferably outside of the process itself. (Laamanen, 2001, p. 155).

Stakeholder views represent very important measurement. Customer satisfaction may forecast if the customer will return or user dissatisfaction may forecast troubles for the process owner in the organisation. Stakeholder views should be enquired and measured timely shortly after the occurrence of the process output. (Laamanen, 2001, p. 157)

4.3 Projects of a process

In order to implement a product or service concept to reality, the development process activities (process steps) can plan and launch projects. Figure 5 depicts interaction between the process and a project. Those projects should provide a planned result in a planned timeframe.

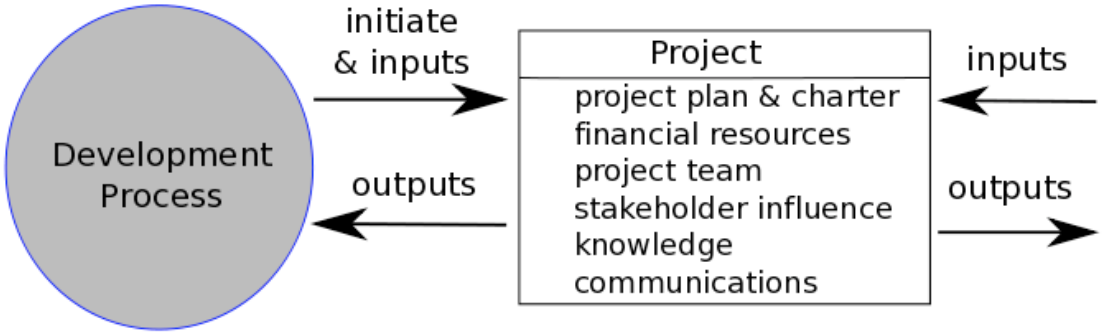

Figure 5. Illustration of interaction related to project and the project essentials

Project managers or organisations can divide projects in to phases to provide better management control with appropriate links to the ongoing operations of the performing organisation. These phases are known as the "project life cycle". (Project Management Institute, 2004, p. 19)

Projects should be divided into phases in the development process. The process should provide those phases for the project and the phases should be included in the project plan.

The transition from one phase to another within a project's life cycle generally involves, and is usually defined by, some form of technical transfer or handoff. Deliverables from one phase are usually reviewed for completeness and accuracy and approved before work starts on the next phase. (Project Management Institute, 2004, p. 20)

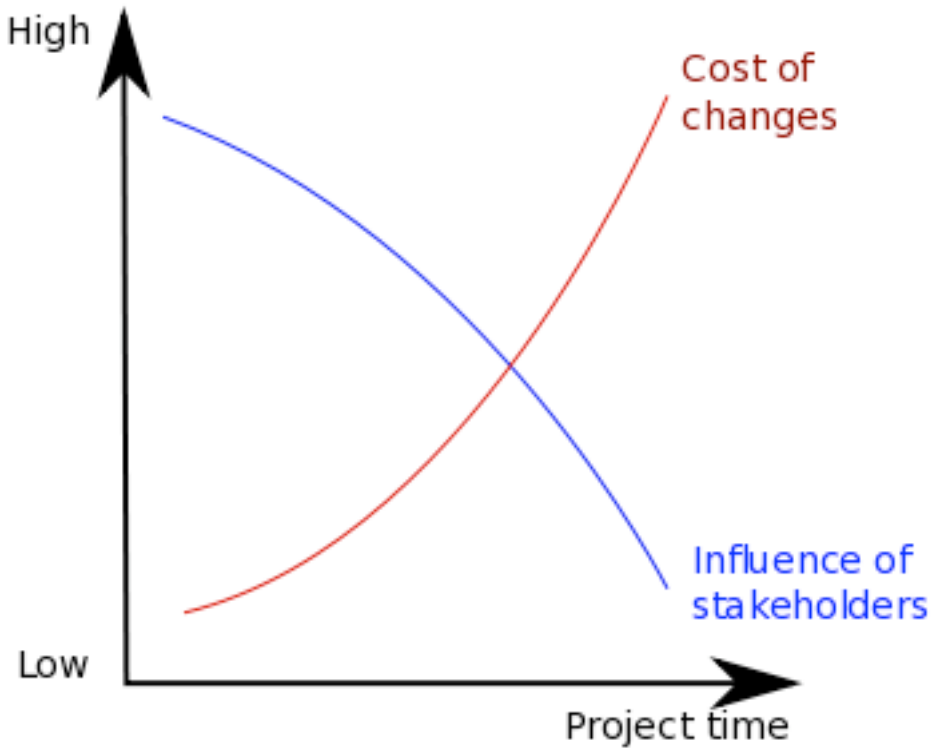

Figure 6. Illustration of stakeholder influence and cost of changes vs. project time

The ability of the stakeholders to influence the final characteristics of the project's product and the final cost of the project is highest at the start, and gets progressively lower as the project continues. A major contributors to this phenomenon are that cost of changes and correcting errors generally increases as the project continues. Figure 6 illustrates the phenomenon. (Project Management Institute, 2004, p. 21)

4.4 Users in the development process

It is important to know the people who use the products that have been developed. Different types of users will have different requirements, and they should be priori-

tised differently (Stevens, Brook, Jackson, & Arnold, 1998, p. 21). The aircrew demographics may differ a lot depending on the country. Therefore the people who develop aircrew equipment should not rely only on general studies of the users.

In this research the aircrew population is 500 people having aged between 20 and 55 years. What does this tells about the users? It tells that there are at least three generations in the group of people. The generations are called Baby-boomers, Generation X and Generation Y. They have had different growth environment and they have different values. Table 12 lists the values for those generations. The 500 population of people means that it is impossible to satisfy everyone's needs and that objective user requirement collection requires statistical methods.

Table 12. Insight to values in life for three generations (Berkeley, 2010, pp. 35,37)

Area of life and values	**Baby-Boomers born 1946-1964**	**Gen X born 1965-1978**	**Gen Y born 1979-1990**
Defining ideas	Individuality	Diversity	Pluralism
Celebrating	Youth	Success	Life
Success	Born winner	Have two jobs	Created own job
Work style	Self-absorbed	Consultant	Entrepreneur
Rewards	Deserve it	Need it	Expect it
Education	A birth right	Way to get ahead	A nuisance
Future	Now	Uncertain	Fix the past mistakes

Money	Spend	Hedge	Working life balance first

According to Czinkota and Ronkainen in order to serve market efficiently, companies must learn what customers want and why they want it (Czinkota & Ronkainen, 2004, p. 189). This can be applied to aircrew equipment development process and the users. In order to maintain or increase user satisfaction towards the equipment, the development process should find out their wants, needs and reasons behind them. Aircrew may need to be divided into sub-groups in order to understand the specific needs, wants and motives of each group.

4.5 Research and development

4.5.1 Relation of research and development

Research is "studious inquiry or examination. Investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws." (Merriam-Webster, 2011). Research supports development. The research is applied to overcome problems and create innovative solutions, which represents the development.

The aircrew equipment development process should sponsor the research that directly or indirectly supports the development. The process inputs like environmental conditions and outputs such as user satisfaction are good examples of research areas. Generally good research areas are those, which support the efficient process, the outputs and recognition of the outputs. Table 13 below introduces a few research areas that support the development.

Table 13. Examples of research areas supporting aircrew equipment development

Nr.	Research area	Description
1	Product research	Understanding the product and improving reliability, usability, operating and maintenance costs, life-cycle etc.
2	User research	Finding, collecting and analysing user needs, requirements and satisfaction to the development. Understanding user behaviour related to the products and services. Understanding human physiological properties and constraints.
3	Use research	Portfolio, configuration and products use preferences and best practices.
4	Environmental conditions research	Climate, micro-climate, camouflage, mechanical accelerations, vibrations and shock, pressure, temperature, etc.
5	Market and weak-signals research	Supply market scanning, new product introductions, emerging technologies, new suppliers in the market, promotions, supply channels, competition in the market, product terminations, market disruptions, market integrations, delivery times etc.

4.5.2 Research resources

Since aircrew equipment consists of various technologies and knowledge areas, the research area is vast. Therefore, it is not reasonable that all of the research efforts of this vast area are in-house research. There are endless possibilities to outsource research in the market. Those vary from universities and research institutes to military research centres and research companies.

The outsourced research needs in-house planning, budgeting and procurement. It also requires guidance, control and contract management in order to be effective. The outsourcing should require clearly less manpower than in-house research. The research outsourcing is basically service procurement where the service is research and its results. Immaterial rights for the research results should be agreed in the research contract.

4.5.3 Aircrew equipment development

According to Anttonen and Vuori (Anttonen & Vuori, 1995, p. 147) development of clothing consists of two different parts, which are:

1. Development activities and manufacturing readiness.
2. Evaluation and measurement of the clothing. Training users to use the clothing.

For a small country, it is not cost-efficient to develop own set of aircrew equipment and maintain the clothing and equipment. Therefore, aircrew equipment should be developed out of existing products by modifying and preparing configurations and portfolios. The suppliers should be kept involved in this development in order to ensure innovation, knowledge base and product lifetime support.

4.5.4 Development resources

According to Henry Mintzberg, it is useful to distinguish between simple innovation and complex innovation. In the first mentioned, the innovation is possible in any organisation and relies on one person or small group. In the latter, innovation may require experts from various business functions to form project teams. This usually requires more resources and involves greater organisational complexity. (Lynch, 2009, p. 475). Aircrew equipment cannot be developed only by one person or small team. This is due to the high cross-scientific knowledge and complex nature of environmental, operational and customer requirements. When assuming that the development resources should include more than one person, it should not mean that the resources consist of large rigid expert section. The solution might be to expand existing base resources based on resource demand. This could be e.g. purpose-built temporary project teams having members from user groups, and experts in-house and outside. When there are several temporary teams developing in various fields, special attention needs to be given to development- and communications management.

Development resources include at least time, infrastructure, knowledge, skills, capital and labour. Development management should use the resources efficiently and if needed, improve the resources available by training or requiring more labour or securing better funding in the future. The training usually increases labour capability and thus leads to greater work satisfaction and knowledge, which may lead to new innovations. Examples of research and development process budgeting methods can be found in table 14 below.

Table 14. Examples of budgeting research and development process

Nr.	Budgeting method	Description
1	Percent value	E.g. percent value of 10 years moving average of yearly aircrew equipment procurement total value.
2	Process R&D capacity	R&D process capacity-based budgeting
3	System R&D capacity	System capacity-based budgeting where constraints in other related processes limit the capacity and thus R&D budgeting needs.
4	Needs and requirements	R&D budgeting is based on evaluated and prioritised needs of the organisation.
5	Fixed budget with inflation correction	R&D budgeting is based on a fixed budget that is increased yearly according to the general price level.

4.5.5 Information systems and tools

Information systems should support the aircrew equipment development process. It may not be possible to use the best available information system software in the market for the process or organisation has approved only limited software configurations for the information system. In this case, the process and the software should be tuned to be efficient as a system.

All gathered, received or processed data should be entered only once (Harmon, 2007, p. 342). This increases efficiency and saves development time because human resources are not needed to perform manual copying of the information. If possible, data collection should be automatised as well. This can be achieved for example collecting user requirements and user satisfaction by electronical forms that can be automatically stored to databases.

The information systems should support all the steps of the aircrew equipment process. The system should be easy to learn and operate. It should also provide good storage, search and data mining functions for learning from development history, tests and studies.

4.5.6 Testing as part of the development

Testing is part of the development process. Testing should provide an answer to the question how well the product meets the specified requirements. The testing should be performed according to international or military standards such as MIL-STD-810G (Environmental Engineering Considerations and Laboratory Tests). Table 15 below gives an example of simple checklist for testing.

Table 15. An example of simple checklist for planning of testing

Nr.	Description
1	Field testing
2	Test users
3	Test groups or units
4	Testing period (process step duration)

5	Sample size (Test cost, test reliability)
6	Reporting form and data collection (Quality)
7	Test standards and procedures (quality)
8	Test approvals, certifications and risk management (safety, security)

4.5.7 Documentation, traceability and re-use

In order to avoid re-work, it is important to document the research, development and testing efforts with results. The documentation offers templates for re-use and thus saving work e.g. in test reports or check lists. Frequently created documents should have templates to speed up the process and improve quality.

If development process needs to be investigated e.g. after a crash, traceability is a requirement. The documents should include information to understand the basis and procedures for decisions made during the development process.

4.5.8 Communications in research and development

Communications support knowledge exchange and discussions that make activities possible in everyday life and in workplaces (Juholin, 2011, p. 30). Telephone calls, e-mails, instructions, orders and process descriptions are part of this communications. In research and development knowledge collection and sharing requires communications. It is an essential part of the R&D.

The communications is also a method for maintaining or developing relations with stakeholders such as users of the products or research institutes (Juholin, 2011, p. 166). Good and sufficient communication helps to reduce uncertainties and produces

confidence between organisations and their stakeholders. Internal marketing is communication. It may include new product or service introductions, strategy implementations etc. It tends to have a positive impact on work performance and satisfaction. The communication helps employees to make commitment with the organisation. (Juholin, 2011, p. 31)

There may be several channels for communications. Those channels include Internet, intranet, bulletins, brochures, Point of Contact persons, meetings, e-mail, seminars, lectures, theme days and open door days. Those channels are divided into direct and indirect. The direct channel involves personal contact.

4.6 Product configuration and portfolio management

4.6.1 Commercial product as part of aircrew equipment

Since it would require plenty of resources from an air force to have their own aircrew equipment design, manufacturing and logistics it is assumed in the research prerequisites that the equipment shall be procured from the existing markets. It means that products in the market will be accepted with or without modifications to be aircrew equipment products. This may require testing or reviews and acceptance procedure before taking into an operational use.

Customers may provide the best source of ideas for new products. Several new commercially important products are initially thought of and even prototyped by users rather than manufacturers. Those products tend to be developed by lead users, who typically are companies, organisations and individuals that are ahead of trends or have needs that are not currently available as products. (Czinkota & Ronkainen, 2004, p. 442). For those who have a role in aircrew equipment development, it is important to recognise internal and external lead users. Those users may offer invaluable suggestions during the development process and they may help to remove change barriers when introducing new products and methods for all users in the organisation.

Shortened product life cycles may lead to spare part availability, configuration and portfolio-management problems for the organisations that purchase the products. Innovative customers or end-users may demand the newest products in the portfolio, even though the collected requirements, the planned product life cycle or associated costs would not support this portfolio increase.

Normally customers are the users of the products and the products are so simple that they do not need to be trained by professionals before use. However, this may not be the case for the survival equipment or aircrew equipment, where the equipment is used for the first time when the conditions force for it. An example of this might be a first aid kit in a family car. When a car accident happens, a member of the family remembers that there is a first aid kit in the car somewhere. It will be searched and used for the first time when the need for it occurs. This should never be the case in military aviation. The aircrews should be trained to use all of their aircrew equipment assets and practise the use of survival equipment periodically. By doing so, the users of the equipment will enhance their chance to survive or limit injuries.

4.6.2 Product configuration for aircrew equipment

System can be defined to be an entity that consists of parts in interaction with each other. Synergy is typical to a system. It means that the value of a system is more than the sum of its parts. (Ristimäki, 2002, p. 12).

If aircrew equipment product would be a part of aircrew equipment system, it should have synergy thus it would be more than a sum of its parts for the users and the customers. Aircrew equipment may be part of weapon systems and then the system complexity and synergy grows significantly.

4.6.3 Portfolio management and logistics

Product portfolios consist of a unified basic product platform and product modules, which are tailored to fit the needs of specific market segments (Hofer;Zimmermann;&

Jekal, 2007). Applying this to aircrew equipment would mean e.g. portfolio for helicopter flying coveralls including normal coveralls and immersion suits. Another example would be a boom microphone and a throat microphone.

How wide should the product portfolio be? In private companies, one could plan the product portfolio to maximise profit. In military it could be the minimum possible to fulfill mission capability, operational requirements, survival and certain level of user satisfaction and flight safety. It should also support work efficiency to provide productivity.

Planning, decision-making and arguing about product portfolio width may be very difficult due to subjective views towards values and personal benefits. Kotler (1994) presents that “A company should not pursue and satisfy every customer”. This should also be the case when planning the portfolio for aircrew. It is impossible to satisfy every customer in the Air Force. The people who participate in the development process should understand this. (Kotler, 1994, p. 52)

4.6.4 Life-cycle management

Life cycle is evolution of a system, product, service, project or other human made entity from conception through retirement. The life cycle can be organised into stages in the framework of processes and activities (International Standardisation Organisation, 2008, s. 4). The life cycle should be breakdown to stages in order to define distinct purposes for each stage. The artificial gap or gates between the stages offer follow-up and decision points for the organisation. The follow-up could concern e.g. cost, schedule and functionality. Examples of stages are product development, testing, commissioning, use and de-commissioning. The development process should get early indication of aircrew equipment product de-commissioning plans in order to develop new replacement product. This could be e.g. a 5-year de-commissioning plan that would be revised annually.

Life cycle management is used to define, maintain and assure availability of policies, life cycle processes, life cycle models and procedures. It should help an organisation to manage life cycles, indicate responsibilities, authorities and provide priorities. Following standards and reports provide information about the life-cycle management: ISO/IEC 15288:2008 Systems and software engineering – system life cycle processes and ISO/IEC TR19760 A Guide for the application of ISO/IEC15288 System life cycle processes (International Standardisation Organisation, 2008, s. 19).

Life cycle management should take into account the product in the system of the organisation. This is especially important from the cost, resource and knowledge point of view. For example, maintenance of an old product may cause more resource use than a newer product.

4.6.5 Procurement

Procurement can be seen as an individual process to which the development process feeds development product or service information and provides resources to finance and support the procurement process. The output of the process include the products, services, trainings, spare parts etc. These are then commissioned in to service according to a plan. The procurement process should have as input at least the point of contact in the development process, description of products, unit prices (or estimate), number of units to be procured, possible supplier list and preferred supplier, delivery address, product acceptance requirements and delivery time requirements.

Procurement process is unique to each country and each organisation. Important issues for aircrew equipment development from procurement point of view are:

1. Is there a need for issuing a public tender? If yes, then what is the tender scope? National, international or selected?

2. Can the product or service be procured using NAMSA?

3. How long a procurement process takes time?

4. Are there any restrictions in the procurement?

5. Who is Point of Contact in technical matters for this procurement?

4.7 Requirements

4.7.1 Introduction

Satisfaction is a person's experience of how his or her needs and expectations are fulfilled. Fulfilment of requirements does not necessarily lead to satisfaction. (Laamanen & Tinnilä, 2002, pp. 73-74). Even though fulfilment of requirement would not lead to satisfaction, it could lead to success.

Systematic requirements management process provides qualification to define a product that fulfils customer (user) needs in a set budget and timeframe. The process also ensures that the product is applicable to the purpose and that intended performance requirements are met. (Pasivirta & Kosola, 2005, p. 22). Requirements management process is not just collecting but managing requirement and acting as capability coordinator. Table 16 gives an example of requirement classification matrix. It has been modified from the list Pasivirta and Kosola have suggested (Pasivirta & Kosola, 2005, pp. 145-146).

Table 16. Requirements classification and collection matrix

N:o	Requirement type	1 Operational	2 Tactical	3 Environmetal	4 User
	1 Constraints				
	2 Design				
	3 Documentation				
	4 Functional				
	5 Infrastructure				
	6 Interface				
	7 Non-Functional				
	8 Performance				
	9 Qualification				
	10 Quality				
	11 Security and Safety				

Requirements should be numbered for explicit referencing. Numbering should include a development project number, requirement type numbers and a requirement running number. An example of such numbering would be requirement 10.4.3.1 where 100 would indicate development project, 4 would indicate that this is a user requirement, 3 would indicate that the requirement is a documentation requirement and 1 would indicate that this is the first requirement.

Requirements should be managed using information systems in order to ensure high productivity and distribution possibilities. That can be done using normal office programs packages such as Microsoft Office, Open Office or similar. There are many commercial software programs for requirements management. An example of such program is IBM Focal Point (http://www-01.ibm.com/software/awdtools/focalpoint/).

4.7.2 User requirements and user needs

A user is the recipient of the product and service process that the user does not directly pay for. The needs of operational users are defined in the user requirements (Stevens, Brook, Jackson, & Arnold, 1998). The profound issue in communications is to understand the users' real needs instead of their written or verbal requirements.

Goal of user requirements collection is to use it as an input in the aircrew equipment development process. The process should provide output based on inputs and this is one of those inputs.

There are many ways to collect user requirements such as directly, indirectly through representatives, e-mails, questionnaires, by phone, word of mouth etc. There are strengths and weaknesses in each of the collection methods and those are important to understand before applying them.

User satisfaction to a certain aircrew equipment product is also a user requirement. If satisfaction towards a product is low, then it means that user requirement is that this particular product should be replaced. User satisfaction should be measured as relative to another product in aircrew equipment range.

4.7.3 Operational requirements

According to Pasivirta and Kosola, operational capability requirements are effectiveness, operational life cycle and availability (Pasivirta & Kosola, 2005, pp. 29-31).

The operational requirements should be provided to aircrew equipment development process by other processes in military organisation or system. The operational requirements are inputs to the process.

4.7.4 Tactical requirements

According to Pasivirta and Kosola, Tactical requirements are command and control, firepower, mobility, durability and logistic support (Pasivirta & Kosola, 2005, pp. 31-35).

Users and other processes in a military organisation or system should provide the tactical requirements to aircrew equipment development process. The tactical requirements are inputs to the process.

4.7.5 Environmental requirements

Environmental requirements are the requirements that are set by an environment external to an organisation. The organisation may have an influence to the fact if some of these requirements are applicable or not. International operations are one good example of them. If the organisation decides that there is no need for international operations, then all environmental requirements appearing only in international operations will come redundant.

The environment and stakeholders-chapter of this research should provide an overview of the environment where aircrew equipment development is acting. The environment and conditions are in constant change. This and the fact that the environment is subjective, leads to the need for environment research in the efficient aircrew equipment development process.

4.8 Analysing Requirements

4.8.1 Requirements and scope analysis

Requirement is something essential to the existence or occurrence of something else. It is something desired or needed. (Merriam-Webster, 2011). The principal requirement for this research is effective development process. It is principal, because it is written in the cover page. In addition the environment where the development is functioning brings in requirements. Operational, tactical, environmental and user requirements must not be forgotten either.

The limitations of scope and related definitions are constraints, which are also requirements for this thesis. Table 17 below illustrates how the scope and definitions are analysed against research, managed and taken into account in the aircrew equipment development process.

Table 17. An example of scope and related definition management

Nr.	Scope, definition or limitation	Description of status or action
1	Should concern clothing or equipment worn, carried or disposable by aircrew of rotary or fixed wing manned aircrafts including helicopters, fast-jets, trainer-, transport- and liaison aircrafts.	The process should create at least three product portfolios that are: 1. Fast-jets 2. Transport and liaison aircrafts 3. Helicopters
2	Should not concern spaceships or very high altitude aircrafts where full pressure suits are in use	Very high altitude or space is not considered in the environment research material.
3	Should concern peacetime development process with domestic and international air operations	Peacetime domestic and international operation environment and their features were introduced in the research.
4	Should concern only military aviation	Only military aviation was considered in this research.
5	Should concern aircrew personnel of 500, aged between 20 to 55 years	Questions about population and values of the generations were discussed in the research.
6	Should concern 8 operating units where aircrew, warehouses and field service functions are located. Distances between the units range from 100km to 800km.	Geography and distances affecting the development process is quoted in the research material. Due to conflicting views between scholars and possible economical interests, the effect of distance on the development

		process should be considered case-by-case and taking in account the advances in communications technology.
7	Should concern one or more depot units where central warehouse, depot maintenance and repair, management, procurement, logistics, research and development functions are located. Distance between depot and the operating units range from 20km to 700km.	See nr. 6.
8	Should not concern wartime development process	Wartime operations were not discussed in this research.
9	No own manufacturing of the equipment	No own manufacturing required. Aircrew equipment markets and procurement features were introduced.
10	In-house repairs and small scale modifications possible	This was not directly discussed in the research material. However, e.g. the expert project teams can implement modifications that support the development process.
11	In-house small scale research and development possible	This was not directly discussed in the research material. Research or development project individuals or teams may perform research and develop-

		ment activities.
12	Should take into account Military Aviation Authority's role in aircrew equipment development and acceptance processes	Military Aviation Authority of England and its roles were introduced in the research material. The roles, responsibilities and authority still depend strongly on country and operating culture.
13	Short-term financing should be planned for each following calendar year, medium-term financing should be planned for the next 5 years in each year and long-term planning for the next 20 years each year.	This has been discussed in process and project budgeting reviews in the research material.
14	The development process should be implemented into typical military organisation model and structure.	Typical military organisation introduced. Process management suitability to military organisation is discussed.

4.8.2 Mind map analysis

Mind map analysis is a visual tool for conception and analysis. The mind map provides a visual examination of the complex, its elements and their relations. It helps structuring the complex through the possibility to communicate and share the conception to others.

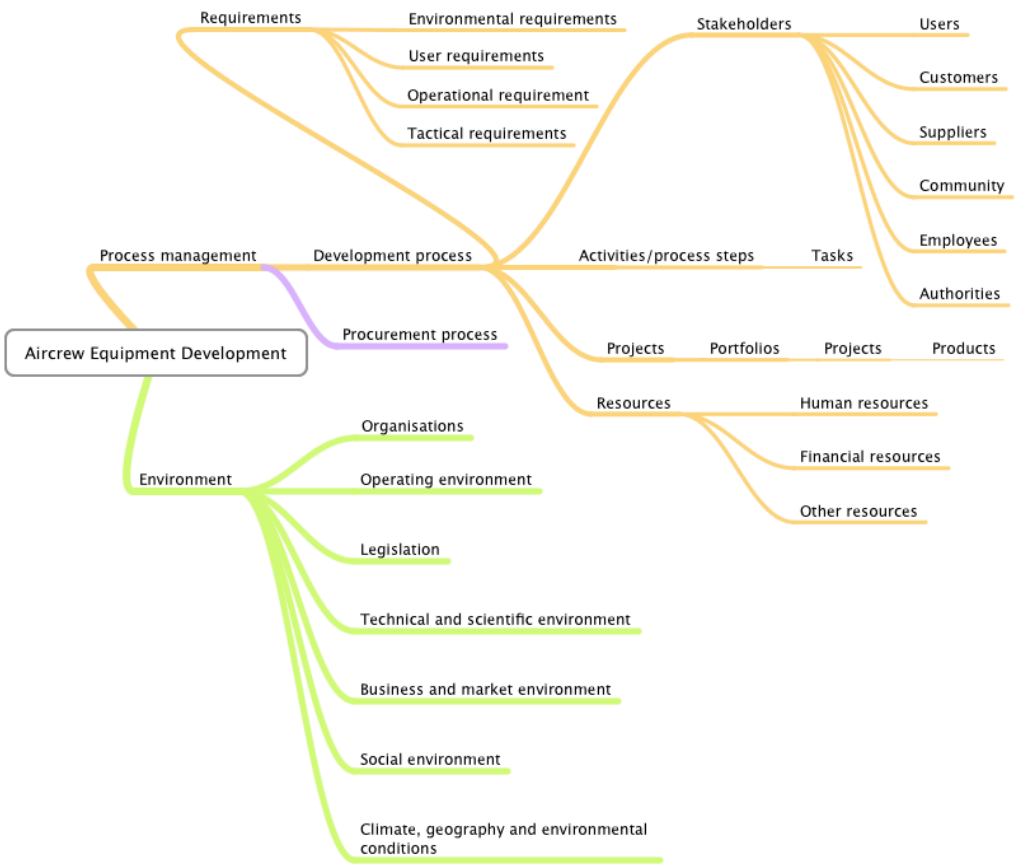

Figure 7. An example of a mind map of aircrew equipment development

The mind map does not only provide a solution to process development, but it can be used for SWOT-analysis for new portfolios, configurations and products. Similarly, it can be used for creating development- and commissioning project teams. The efficient conception of mind map and communication features makes it ideal for teamwork purposes. Figure 7 introduces aircrew equipment development process environment through an example.

4.8.3 List of the most important issues affecting the development process

The list of the most important issues affecting the development process of aircrew equipment development is difficult to create, if the environment is not real. This re-

search is generic, so there are not any real environments to measure. The environment has a huge impact on what methods or practices should be chosen when reaching for affectivity.

There are some general, process related issues that have huge impact on the process performance. Those general principles are applicable in almost any process. The principles are created based on this research and are listed in the table 18 below.

Table 18. The most important issues affecting the aircrew development process performance

Nr.	Description of affecting issue
1	Periodically review and measure process performance with metrics. Improve process periodically.
2	Create portfolios to break aircrew equipment into smaller, easier-to-handle entities. Do not break in too small pieces to avoid chaos and configuration management problems.
3	Keep information easily accessible for stakeholders and team members.
4	Plan and communicate development projects well in order for them to be efficient and thus shorten the process step time.
5	Plan process timing and cycle according to the financing timeline. In public sector money has a best before date and strict rules for the use.
6	Evaluate user requirement inputs only periodically. Create a form to enforce the user to fill all essential information once. Then there is no need for checks or call-backs.

7	Provide complete and error free orders to procurement process.
8	Develop and match employee skills and knowledge with roles.
9	Keep the amount of changes low during procurements or projects. Plan well ahead and check against plans.
10	Get well connected and promote this to people who work in the process. This will reduce the information and knowledge access time and costs.
12	Be prepared for constant change, but keep process variation small.
13	Measure user satisfaction in order to be effective, not just efficient.
14	Reduce process complexity; tackle easy, high reward part first.
15	Enter data only once in the process information systems. If possible, automate the data collection.
16	Use standards for Request for Quotations, for information re-use and interoperability.
17	Build confidence with stakeholders by communications.
18	Use lead users for smoothing the road for new products.
19	Create and update a list of soon to be de-commissioned products for re-source management.

5 DEVELOPMENT PROCESS PROPOSALS

The development proposal 1 has been created and revised a few times based on the iteration of the research and analysis. A system level example in appendix 1, where the development process is part of a system, has given good understanding about environment internal to an organisation. An interfaces list creation in appendix 2 enforces to think about the system and its flows.

The process starts with Research step and ends to De-commissioning step. It has 13 chronological steps, which all have specific goals and tasks. Those steps are derived from the required output, input, stakeholders and environment introduced earlier in this thesis. The process cycle time depends on the environment, where it would be implemented.

The proposal 1 is depicted below in figure 8. More detailed information about the proposal can be found in table 19, which also includes process step names and short process descriptions.

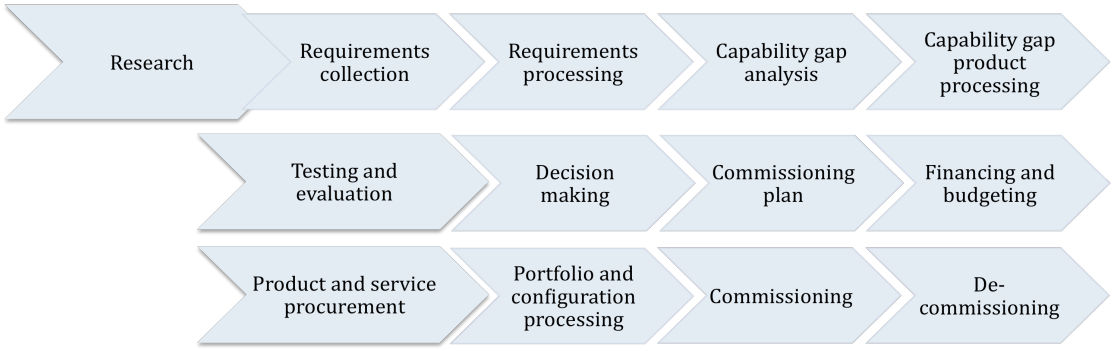

Figure 8. The development process proposal 1

Table 19. The development process proposal 1 with step descriptions

Nr	Process Activity or Step	Description of actions
1	Research	Study and research products, portfolio, use, user, environment, relevant standards and agreements, weak signals, life-cycles and launch research projects
2	Requirements collection	Requirements data collection and listing
3	Requirements processing	Requirements data analysis, processing to information and categorisation
4	Capability gap analysis	Comparing existing product portfolio to requirements information, Analyse requirement needs to product features gap(capability gap), check against waiting list
5	Capability gap product processing	Find gap products from market starting highest priority gap product, evaluate feasibility, life-cycle, availability and pricing
6	Testing and evaluation	Test and evaluate products if possible, launch test project if required
7	Decision making	New product SWOT-analysis, decide to proceed with new product development, Check if suggested new product could replace one or more products in the product portfolio, check authority compliance
8	Commissioning plan	Plan portfolio, configurations, life-cycle, maintenance, training, IT requirements, risks, testing, acceptance, estimate total costs including operating costs (jump to 5)
9	Financing and budgeting	Find financing for a new products, if not, cancel development for the product and move it to waiting list
10	Product and service procurement	Send the development product or service procurement order to the procurement process
11	Portfolio and configuration processing	Add new products to portfolio with configurations, check if a products can be removed from portfolio
12	Comissioning	Start comissioning project of the new product
13	De-comissioning	Start de-comissioning project of the product to be replaced

The proposal 2 is depicted below in figure 9. It is almost similar to the proposal 1. The only changes are the Financing and budgeting step is number 8 and Commissioning plan is number 9. This difference is due to financial planning and commissioning risk

management. More detailed information about the proposal can be found in table 20, which also includes process step names and short process descriptions.

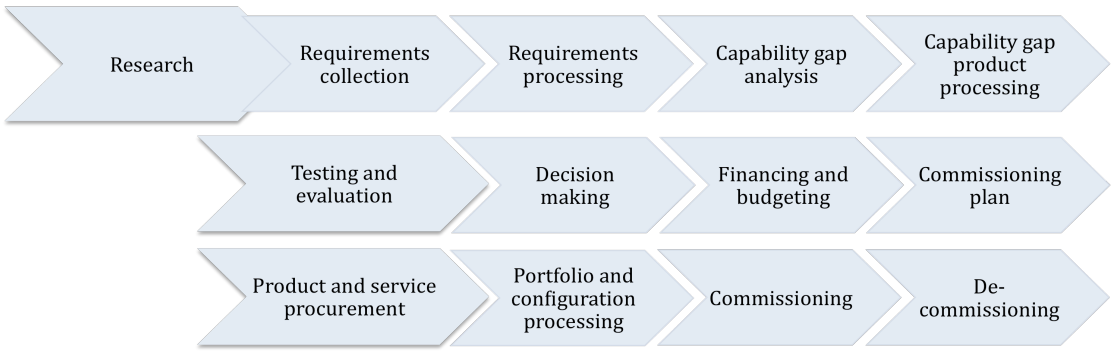

Figure 9. The development process proposal 2

Table 20. The development process proposal 2 with step descriptions

Nr	Process Activity or Step	Description of actions
1	Research	Study and research products, portfolio, use, user, environment, relevant standards and agreements, weak signals, life-cycles and launch research projects
2	Requirements collection	Requirements data collection and listing
3	Requirements processing	Requirements data analysis, processing to information and categorisation
4	Capability gap analysis	Comparing existing product portfolio to requirements information, Analyse requirement needs to product features gap(capability gap), check against waiting list
5	Capability gap product processing	Find gap products from market starting highest priority gap product, evaluate feasibility, life-cycle, availability and pricing
6	Testing and evaluation	Test and evaluate products if possible, launch test project if required
7	Decision making	New product SWOT-analysis, decide to proceed with new product development, Check if suggested new product could replace one or more products in the product portfolio, check authority compliance
8	Financing and budgeting	Find financing for a new products, if not, cancel development for the product and move it to waiting list
9	Commissioning plan	Plan portfolio, configurations, life-cycle, maintenance, training, IT requirements, risks, testing, acceptance, estimate total costs including operating costs (jump to 5)
10	Product and service procurement	Send the development product or service procurement order to the procurement process
11	Portfolio and configuration processing	Add new products to portfolio with configurations, check if a products can be removed from portfolio
12	Comissioning	Start comissioning project of the new product
13	De-comissioning	Start de-comissioning project of the product to be replaced

6 EVALUATION OF THE DEVELOPMENT PROCESS PROPOSALS

Evaluation is determining the significance, worth, or condition by careful appraisal and study (Merriam-Webster, 2011). Evaluation should be systematic and performed against standards.

The purpose of this evaluation is to estimate the value of proposal 1 and proposal 2 for the effective development process of aircrew equipment. The evaluation outcome should be the proposal that is more valuable for the organisation, system and the customer. The evaluation was carried out by analysing the proposals 1 and 2 from stakeholders' point of view. Technically it was performed in table 21, where proposals were rated from each perspective. The point range was from -1 to +2 points. Most points in the end suggest the most effective proposal.

Table 21. The proposal evaluation table

Nr.	**Perspective**	**Value Proposal 1**	**Value Proposal 2**
1	Customer	Fewer risks with new products since commissioning plans are done before financing decisions. (+1p)	Less work (1/13) performed wasted if financing is not granted for a new product. (+1p)
2	User	If user participates in the commissioning plan work and the financing is not secured, some work	Certainty of new product introduction available earlier (1/13). (+1p)

		will be wasted. (-1p)	
3	Organisation / system	Budgeting is more accurate due to plans available. (+1p)	-
4	Efficiency	-	If financing is not sure for many new products, the efficiency is better because the amount of waste is less. (+1p)
5	Process cycle time	-	-
6	The research	-	If following: "Plan process timing and cycle according to the financing timeline." There are fewer steps left in the process after the financial decision is made. Definitely better than PS1. (+2p)
SUM	**Total points**	**+1 point**	**+5 points**

According to the evaluation in table 21, process proposal 1 reached to +1 points and proposal 2 earned +5 points. Based on the evaluation, the proposal 2 was clearly more valuable than proposal 1.

7 SUMMARY AND CONCLUSION

7.1 Success and key Success Factors

The research met its goals. Research problems were solved and documented. Those problems were: 1) Research and analyse issues that affect efficiency of aircrew equipment development process. 2) List of most important issues affecting the development. 3) Derive general example of effective development process.

Key success factor for the research and the process creation was availability of references. 30 years ago this kind of research would have been very difficult or impossible to perform with low budget and single person work. The Internet and good library services have made this kind of information availability on processing possible.

Another success factor was the researcher's civilian work history and studies outside of engineering discipline that brought a wider view to this research work and especially commercial and value point of view.

7.2 Further research possibilities and suggestions

There are further research possibilities derived from this research. For example outsourcing and development process would an interesting area of study. For example, if the development process labour resources are not sufficient enough, could outsourcing help the process? And how should it be done in order it to be effective and relatively risk free.

Another research area would be the implementation of good quality control system in the development process. It would be interesting to find out the effect of a quality control for development costs and user satisfaction levels.

Then one interesting, but more general process development tool would be simulation of the revised processes before use. How could it be done so that it would provide an added value for the process development work.

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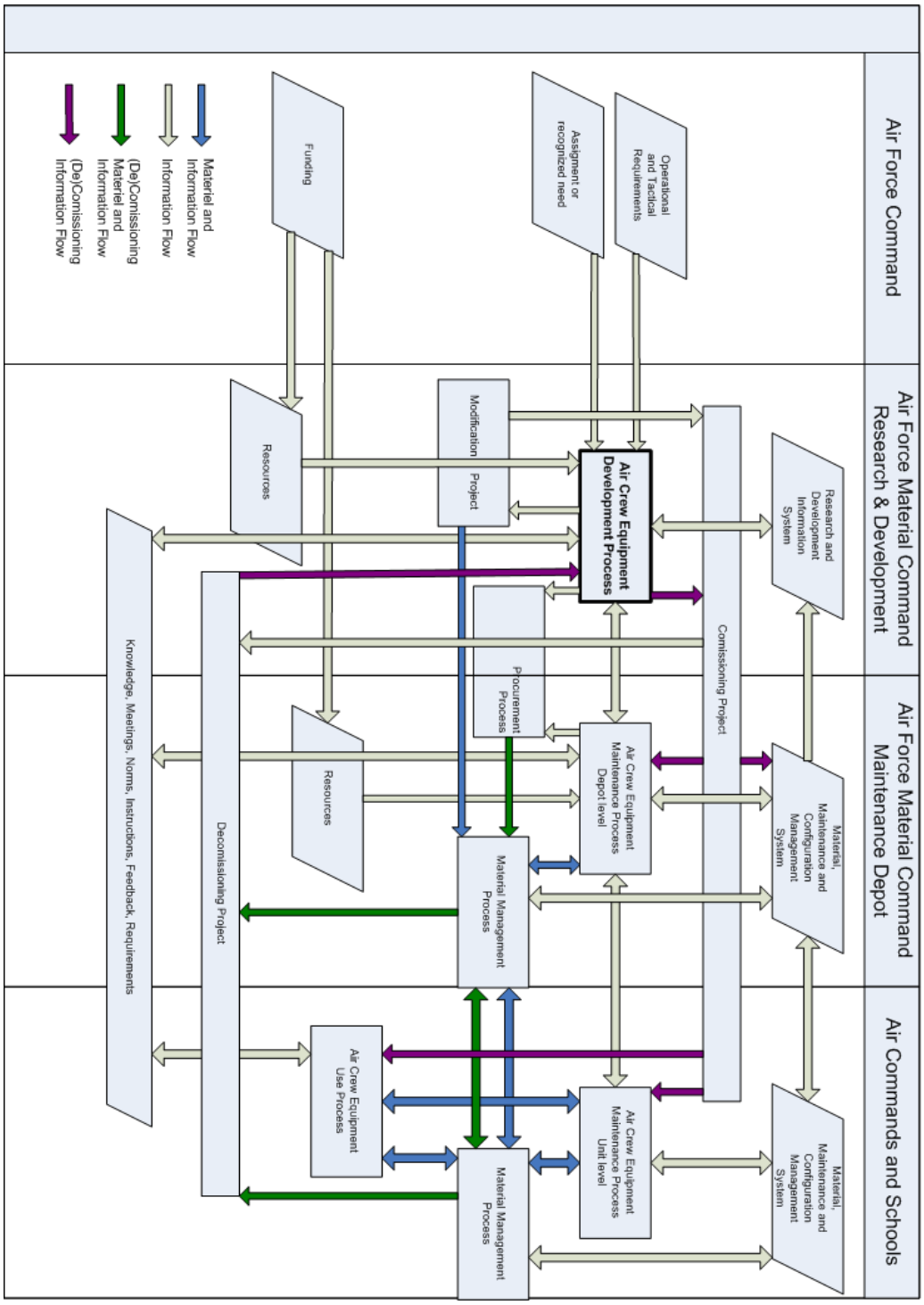
APPENDIXES

Appendix 1: Aircrew equipment process in an example system



Appendix 2: Interfaces

N:o	Interface	Function	Description	Method
1	Internal	Resources	Manpower, funding	
2		Modification project	Modification plan	
3			Modification assignment	
4		Information System	Information management	
5		Procurement	Procurement request	
6		Knowledge etc.	Feedback	
7			Instructions	
8		Comissioning Projects	Comissioning plan	
9			Comissioning assignment	
10		Decomissioning Projects	Decomissioning plan	
11			Decomissioning assignment	
12	AFC	Operational requirements	Requirements list	
13			Operational scenarios	
14		Tactical requirements	Requirement list	
15			Tactical scenarios	
16		Assignment or need	Capability assignment	
17		Funding	Transfer of funds	
18	AFMC Maint.	ACE Maintenance Process		
19		Capacity Constraints		
20		MMCM System		
21	AC	ACE Use Process	Use scenarios	
22			Feedback	
23	External	Research Institutes	Environmental conditions	
24		Authorities	Norms, supervision	
25		Suppliers	Products, Services, Information	